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AUTHOR Kurz, Gunther; And Others
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ABSTRACT

Computer Assisted Training (CAT) is a research project at the Fachhochschule fur Technik in Esslingen, West Germany; the aims of this project are to develop and evaluate new means and methods of instruction giving the student a more active part. Special emphasis is given to the computer as an instructional aid, mainly for drill and practice. This project is described under the following headings: CAT's integrated media model, computing facilities and CAT programs, evaluation of teaching methods, and summary of results and conclusions. (VT)

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COMPARING TRADITIONAL AND MODERN WAYS OF TEACHING ENGINEERING STUDENTS MATHEMATICS AND PHYSICS

by

Gunther Kurz
Rainer Eggensperger
Gunnar Voss

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Günther Kurz, Rainer Eggensperger, Gunnar Voss

Projektgruppe CAT
Fachhochschule für Technik
Mühlstr. 1
7300 Esslingen, W-Germany

1. EDUCATION AT FACHHOCHSCHULEN

CAT (Computer Assisted Training) is a research project *) at the Fachhochschule für Technik in Esslingen, W-Germany. Similar to a college of engineering the Fachhochschule für Technik offers a practice-oriented higher education in technical subjects. The study leads to a degree in engineering (graduated engineer). It takes four years that is eight semesters including two spent in industry. It can be divided into two parts: the foundation studies and the main studies.

The aims of the project are to develop and evaluate new means and methods of instruction giving the student a more active part. As the name of the project implies special emphasis is given to the computer as an aid of instruction, mainly for drill and practice.

Up to now the project has been concerned with students in the foundation studies in the department of mechanical engineering. The chosen subjects have been mathematics, physics and technical thermodynamics. For the main studies the program 'Finite Elements' has been developed as an aid in mechanical design.

During his training the student spends a weekly average of 28 hours at lessons. During the foundation studies 90 % of this time is spent on lectures and only 10 % on practical work and exercises.

2. CAT's INTEGRATED MEDIA MODEL

It is our idea to reduce the time used for lectures to about one half and use the other half for more active ways of learning.

The media model comprises:

- reduced lecture
- course booklet
- small group work with tutors
- selection of exercises and model solutions to the problems
- computer programs
- tests for self-evaluation

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The lecture gives an overall view of the subject and is meant as a guideline for the students. The illustrated course booklet covers the topics more extensively. It is printed in such a way that the student can add notes and it contains a glossary of important terms. Exercises are done in small groups and by computer assignments. These aids are organized in such a way that they can also be used without the computer programs. This is important as still most Fachhochschulen lack the necessary hardware facilities. The tests have a twofold purpose: in the first place the student can check his understanding of the material and secondly the efficiency of different teaching methods can be assessed.

Up to now the components of this media model have been developed for the following instructional units (each encompassing about 20 teaching hours):

Mathematics	- vector calculus - matrix calculus - integral calculus I and II - complex numbers
Physics	- heat and thermodynamics - electricity - oscillations
Technical Thermodynamics	- ideal gases

3. COMPUTING FACILITIES AND CAI PROGRAMS

For three years we were connected to a distant large scale computer (SIEMENS 4004) using two and for a short period up to six teletype terminals. In 1977 we could only use two IBM 5100 minicomputers. In 1978 we will have a PDP 11/34 at our disposal together with six display terminals (five HP 2641 A and one Tektronix 4013). First using PLANIT we switched to APL two years ago.

Up to now some 20 CAI programs have been developed in the following areas:

- vector calculus
- matrix calculus
- integral calculus
- oscillations
- ideal gases

The CAI programs in the instructional unit 'Vector Calculus' deal with the basic rules of vector algebra, vector products and geometrical applications of vectors.

The programs of the unit 'Matrix Calculus' cover the basic properties of determinants, evaluation strategies for determinants, matrix multiplication and inversion.

The programs of 'Integral Calculus' deal with the properties and applications of definite integrals, the integration of elementary functions and some special methods of integration.

The programs of 'Oscillations' deal with the basic notations and relationships, simple and damped harmonic motion, forced oscillations and resonance.

The programs in 'Ideal Gases' deal with the properties of ideal gases and thermodynamic cycles.

4. EVALUATION OF TEACHING METHODS

In order to compare the efficiency of different methods of instruction the project CAT has constructed achievement tests for each instructional unit. For some units there are also course-entrance tests measuring the preinstructional knowledge of the students at the beginning of an instructional unit. These tests all use the multiple-choice format. In addition there are questionnaires to find out the attitude of the students towards the different teaching methods used.

One condition of the federal grant was to test the developed printed aids of instruction at many Fachhochschulen in the Federal Republic. To achieve this we first tried to get the comments of as many students, tutors and faculty members as possible for a formative evaluation of the material. The second objective was to get colleagues at other Fachhochschulen interested in our approach of teaching. This we judge to be a very essential objective as it compensates for the high initial costs, and fortunately we were successful in gaining the cooperation of colleagues at 31 Fachhochschulen out of some 60 in the Federal Republic.

Instructional Unit	Complex Numbers		Integral Calculus I		Oscillations		Ideal Gases	
Teaching Method	L	M	L	M	L	M	L	M
Number of Students	76	76	72	69	54	49	18	13
Preinstructional Test Score	.57	.58	.39	.39	.30	.36	.45	.53
Achievement Test Score	.49	.54	.29	.28	.27	.31	.21	.24

Table 1 Mean test scores from 14 experiments carried out in divided classes. 'L' stands for lecture and 'M' stands for media model.

The preinstructional test score is the fraction of the items solved correctly. The achievement test score is the fraction of the difference between posttest and pretest points divided by the difference between maximum number of possible points and pretest points.

In a first phase we compared traditional lecturing with our multi-media model in some 60 classes half of them using the CAT material. The achievement was measured under both conditions. Later on both teaching methods were used by the same lecturer his class being divided into two equivalent parts. 14 experiments of this kind were carried out. The results are summarized in Table 1. Up to now only four experiments comparing CAI with lecturing could be performed. The reason for this was the restricted number of terminals available.

5. SUMMARY OF THE MAIN RESULTS AND CONCLUSIONS

- The teaching by the CAT media model leads to a higher or at least the same level of achievement as traditional lecturing.
- The printed material is easily transferable but there are difficulties with the computer programs with this respect.
- Colleagues at other Fachhochschulen are interested to use the CAT material.
- The students show a positive attitude towards this new approach of teaching.
- There is a high correlation between achievement and preinstructional knowledge.
- The low level of preinstructional knowledge indicates a need to organize additional courses for the students to compensate for their deficiencies.
- It might be expected that future experiments will show more clearly the potential of the CAT media model provided the students have a sufficient preinstructional knowledge.

We thank all persons who have been involved in this investigations mainly the members of the Projektgruppe CAT and all institutions supporting us.